Intelligent Assistants for Flexibility Management (Grant Agreement No 957670)

D7.4 Validation framework and plans

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Arso Savanović	2021-06-22	Accepted with minor comments.

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1 Executive summary

The main objective of this report is to describe the validation framework and plans, more specifically to answer questions:

1. What should be validated within the project?
2. Who should validate?
3. When to validate?
4. What methods and data should be used to perform the validation?

Further on the objective of this document is to serve as a basis for performing validation of pilot solutions through three pilot phases in three different countries, namely Finland, Greece and Slovenia.

Validation framework and plan includes the general process of validation, namely how the validation should be performed, as well as details for: End user validation, Technical validation, Business validation, Validation of DoA Project KPIs.

2 Introduction

The iFLEX project is a response to the call LC-SC3-EC-3-2020, entitled “Intelligent Assistants for Flexibility Management”, of the Horizon 2020 program. Key objectives of the iFLEX project are:

- To develop AI-enabled modelling, optimisation and user interface methods for consumer flexibility management and load forecasting.
- To design and develop modular, secure and interoperable interfaces and data management services for consumer flexibility management.
- To design and implement novel user engagement, incentives, and market mechanisms for consumer-centric demand response, whilst respecting consumer rights.

The various modules developed by the solution providers, which are involved in the project, will be integrated into a holistic software framework for flexibility and energy management, namely the iFLEX Framework. The iFLEX framework and application-specific iFLEX Assistant prototypes, customised for DR services provided by the industrial partners of the project, will be deployed and tested through pilots in three different countries: Finland, Greece and Slovenia. More than 600 consumers will be part of the pilots, mainly comprising residential buildings but also small industries and a supermarket. In addition, the validation in the three pilots will mainly focus on the following areas:

- To demonstrate the applicability of the iFLEX Assistant prototypes for minimizing the imbalances and harnessing the flexibility of smart homes in Southern European climate.
- To demonstrate the iFLEX Assistants in efficient operation of the electricity grid with high share of RES in Central European climate.
- To demonstrate the iFLEX Assistants in the context of holistic flexibility management services in Nordic climate.
- To design and execute common validation for iFLEX Assistants demonstrated in the three pilot clusters.

2.1 Report Objectives

The main objective of this report is **to describe the validation framework and plans**, more specifically to answer questions: What should be validated within the project, Who should validate, When to validate and What methods and data should be used to perform the validation. Further on the objective of this document is **to serve as a basis for performing validation** of pilot solutions through three pilot phases in three different countries: Finland, Greece and Slovenia (pilot details and background can be found in chapter 2.1.1). The objective of the document is also **to communicate the need for documenting validation results** to all project partners.

The report aims to present the overall process of the validation as well as details for: End user validation, Technical validation, Business validation and Validation of Project KPIs.

2.1.1 Pilots Context

The iFLEX Framework will be demonstrated and validated in three different pilot clusters with their own focus areas. In this context, application-specific iFLEX Assistants will be developed by using the iFLEX Framework modules and then integrated to the DR and holistic energy management services provided by project industrial partners. These services include:

A. flexibility aggregation services for energy markets operated by ECE and HERON,

B. RES aggregation services operated by OPTIMUS,

C. technical DRM services provided by ICOM and SCOM,

D. distribution management system operated by ELE,

E. ESCO-type services provided by CAVERION, and

F. flexibility market platform for utilities and retailers provided by ENERIM.

A summary of the pilot clusters to be deployed over the three phases is presented in the following table (Table 1).

Table 1: Summary of pilot clusters

Cluster Type	Focus	Energy Vectors	Type of Loads	Production & Storage	Consumer Types	Building Types
Greek	Integration of smart homes into the grid. RES and DSF aggregation (VPP) for energy market operation.	Electricity, heat	smart devices, water heaters	PVs	Residential	Subset of 200 households
Slovenian	Integration of high share of RES; efficient operation of the power grid. Aggregation of flexibility for peak reduction and RES integration.	Electricity	home appliances, industrial loads	PVs, small HPP	Residential Industrial	100 homes & small enterprises
Finnish	Holistic energy mngt; Local aggregation at apartment building and district levels. Link with INTERRFACE for DSO/TSO DR markets.	Electricity, district heating, waste heat	heat pumps, lighting, freezers & coolers, appliances	Thermal mass of the building as heat storage	Residential Commercial	Block of apartments & supermarket

2.2 Document outline

Addressing the main objectives of the project's tasks contributing in this report and its audience, this document is structured as follows:

- Chapter 1: Executive summary
- Chapter 2 (the present section) is an introductory chapter for the report;
- Chapter 3 describes the Process and Methodology of validation
- Chapter 4 presents Validation framework and plan for each item of validation during pilot phases;
- Chapter 5 summarises the main conclusions of this work.

2.3 How to read this document

This content of the document is of interest to both technical partners (e.g. software architects, requirements engineers, testers) and business partners (Distribution System Operator, Retailers, Aggregators) who need to understand what validations are planned within pilots and what baseline data should be collected to perform the validation.

The most important is Chapter 4 where planned validations are described with details and also names of responsible partners who should perform the validation with stakeholders. The document should be read by all project partners, except end users (consumers, prosumers). Chapter 4 should be considered as a validation plan that requires project partners agreement. When agreed it should be followed by responsible validators and stakeholders to successfully perform the validation tasks.

The majority of validations are related to user, functional and non-functional requirements as well as business model and services requirements. It is recommended for readers of this report to get familiar with WP2 and WP5 deliverables prior to reading validation details in Chapter 3 and 4.

For the readers from general public the most valuable content is in Chapter 3 where readers could get the insight into the methodology of validation and the process of validation incorporated into the software development life cycle of iFLEX.

3 Validation Methodology and process

3.1 Definition, purpose, objectives and scope of validation

Validation is recognized in Software Development Life Cycles as important task or sub-process contributing to the usability, usefulness and satisfaction with the product which all influence to overall user experience and the quality of the software. Despite many available definitions, the most commonly used definition of validation could be found in methodologies and standards used among professionals in project management, business analysis and software development life cycle (IEEE, BABOK, PMBOK).

Validation:

The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders. It often involves acceptance and suitability with external customers.

The purpose of the validation is to ascertain that the system and/or services meet the needs of its intended users. The objective of the validation work is thus to obtain feedback of the applied technologies from all stakeholders involved in order to evaluate the benefits of the iFLEX Framework and application-specific iFLEX Assistants against the **KPIs** as well as the **requirements collected during the project**. Validations, planned in this document, includes both formative and summative validation approach and combined with a participatory validation approach where the actual end-users in the two trials are invited to evaluate iFLEX Framework based on their involvement in the pilot demonstrations. Both quantitative and qualitative research methods will be used.

Formative vs. Summative: **Formative validation** is used during the early stages of the design and development process, using solution specification, documentation and prototypes to find for example issues with user interface design and solution functionalities and to solve those during the early stages of the development process. **Summative validation** is an evaluation of a complete or near-complete design under realistic conditions that can be used to determine/test if the design meets specific measurable performance and/or goals, or to establish a usability benchmark or to make comparisons.

Following validations are planned for iFLEX Framework and application-specific iFLEX Assistants (details are provided in next sections of the Validation Framework):

1. End user validation
2. Technical validation
3. Business validation
4. Validation based on the Description of the Action (DoA) document (Project KPIs)

Validations will be accomplished during 3 pilot phases in 3 pilot clusters using different methods:

- Phase 1 – Pre-pilot Validation - Formative validation - (Wireframes, Designs, Concepts, Prototypes)
- Phase 2 – Small-scale pilot Validation - Formative and Summative validation
- Phase 3 – Large-scale pilot Validation - Summative validation

Some validations will be performed in all pilot phases and clusters, iteratively, and some of them only in specific pilot phase and only once (one off). The idea and the logic of validation structure and phases are presented in Figure 1. Further details about the validation framework and plans are provided in chapter 4.

	Pre-pilot Validation			Small-scale pilot Validation			Large-scale pilot Validation		
	GRE	SLO	FIN	GRE	SLO	FIN	GRE	SLO	FIN
End user validation									
User acceptance and satisfaction	●	●	●	●	●	●	●	●	●
End-user requirements	●	●	●	●	●	●	●	●	●
Technical validation									
Functional requirements	●	●	●	●	●	●	●	●	●
Security requirements				●	●	●	●	●	●
Non-functional requirements				●	●	●	●	●	●
Architecture requirements				●	●	●	●	●	●
Business validation									
Business use case	●	●	●	●	●	●	●	●	●
Business incentives				●	●	●	●	●	●
Business model and services							●	●	●

Figure 1: Validation plan logic and structure

The validation of iFLEX Framework and application-specific iFLEX Assistants will focus mainly on three perspectives of the product while answering several key questions for intended end-users and stakeholders – like presented in Figure 2.

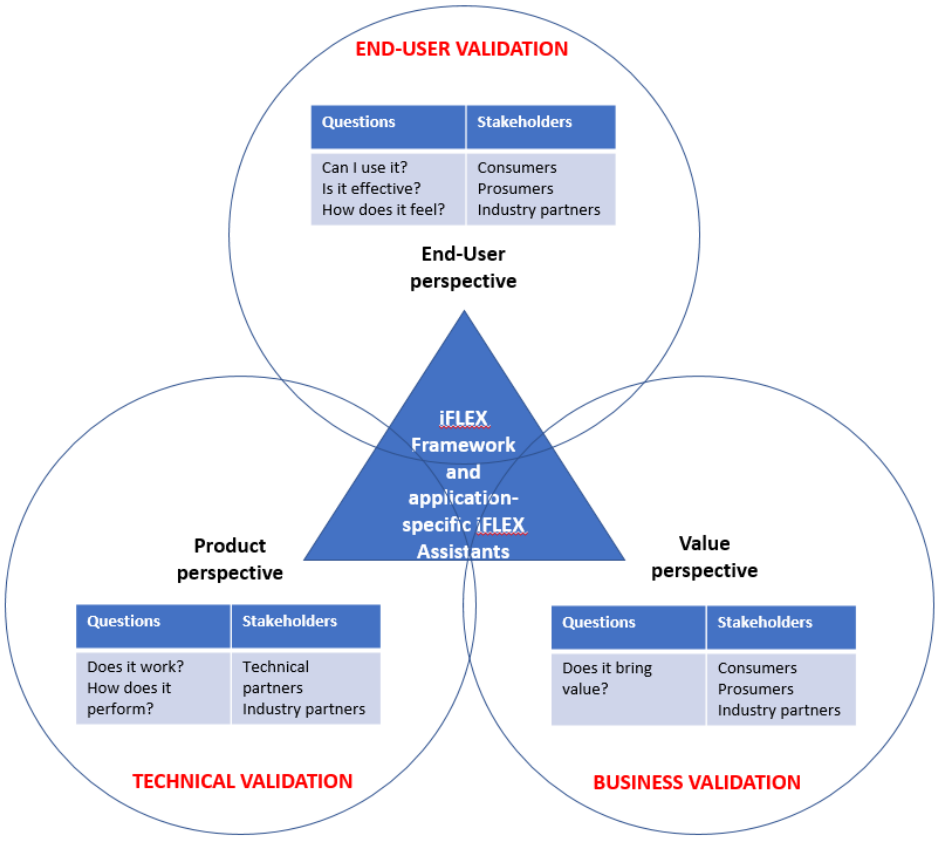

Figure 2: Main perspectives of validation

3.2 Validation process within the agile development lifecycle

The validation activities will be aligned with the agile software development process. Hence, validation activities will be undertaken in accordance with the planned instantiation of pilot demonstration periods. During each validation period, baseline data will be collected, the relevant validation tools will be developed, and the validation data will be collected. Based on the iterative approach to demonstrations in the project, the collected data will be used to feed back into the development work for optimising the iFLEX Framework, and for planning the strategies for end-user engagement and the business models. This work will be carried out in all three pilots in alignment with each pilot's validation plan.

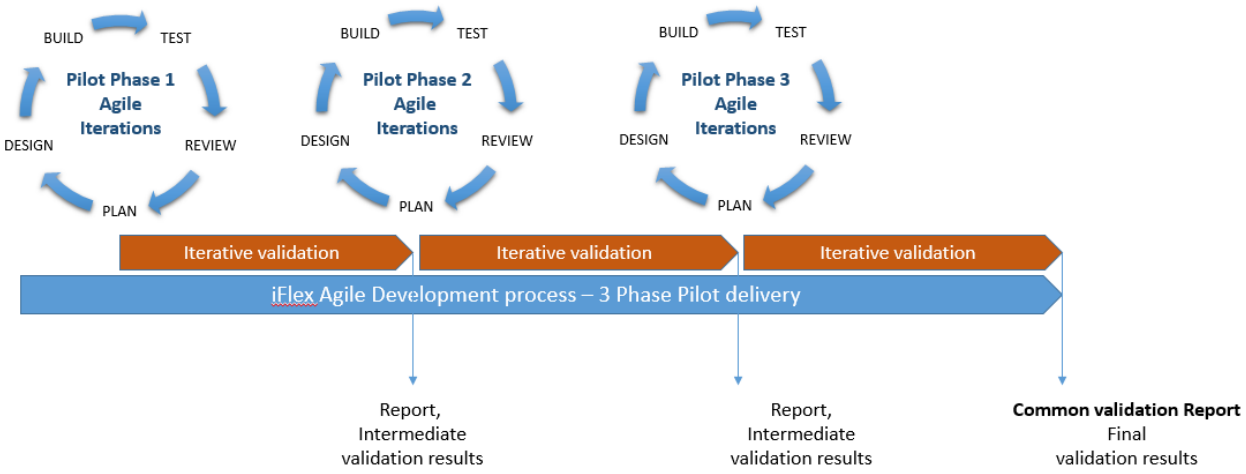

Figure 3: Iterative agile development including iterative validation

The development process is composed of three iterations. The goal of the **Phase 1** is to co-create and **validate a minimum viable product (MVP)** of the iFLEX Framework and application-specific iFLEX Assistants and deploy them into a pre-pilot consisting of few selected users in order to collect feedback and validate against the functional requirements. In the **Phase 2**, the feedback from Phase 1 is utilized to improve the iFLEX Framework with new functionality and better user experience. At the end of this phase, the improved iFLEX Framework and Assistants developed on top of the framework have been **validated with small-scale pilots**. In the **Phase 3**, any missing functionality is added, and the focus is then on fine-tuning the quality of service (QoS) and user experience based on the Phase 2 feedback. At this phase the pilots are also scaled up in order to collect feedback and **validate the Final iFLEX Assistants in large-scale**.

3.2.1 iFLEX individual validation iteration

Each individual validation iteration should consist of three steps where specific inputs are prepared and outputs delivered at the end of validation.

Validation preparation task is a responsibility of **validation coordinator** for specific validation item *(details in next chapter Validation framework and plan)*. Validation coordinator should ensure that needed inputs for validation are available, to coordinate the validation plan with validators, train validators if needed, prepare tools for validation, prepare or gather validation (baseline) data (even prior to validation if needed), refine validation method, prepare the validation reporting template.

Validation is the core validation task of iFLEX Framework and application-specific iFLEX Assistants. It is a responsibility of **validation coordinator** who coordinates the task with validators according to the plan and selected method and/or tools for validation.

Validation reporting should take care of finalizing and documenting results and reports of validation. Some validation results are important to provide an input for the next development iterations and some of them are important to deliver promised value and KPIs as defined in DoA. The validation coordinator should take care of updating the status of validation in the common validation framework and plan to have the clear understanding what validations were performed, when, where are the results, etc.

Figure 4 presents the individual iteration steps with inputs and outputs.

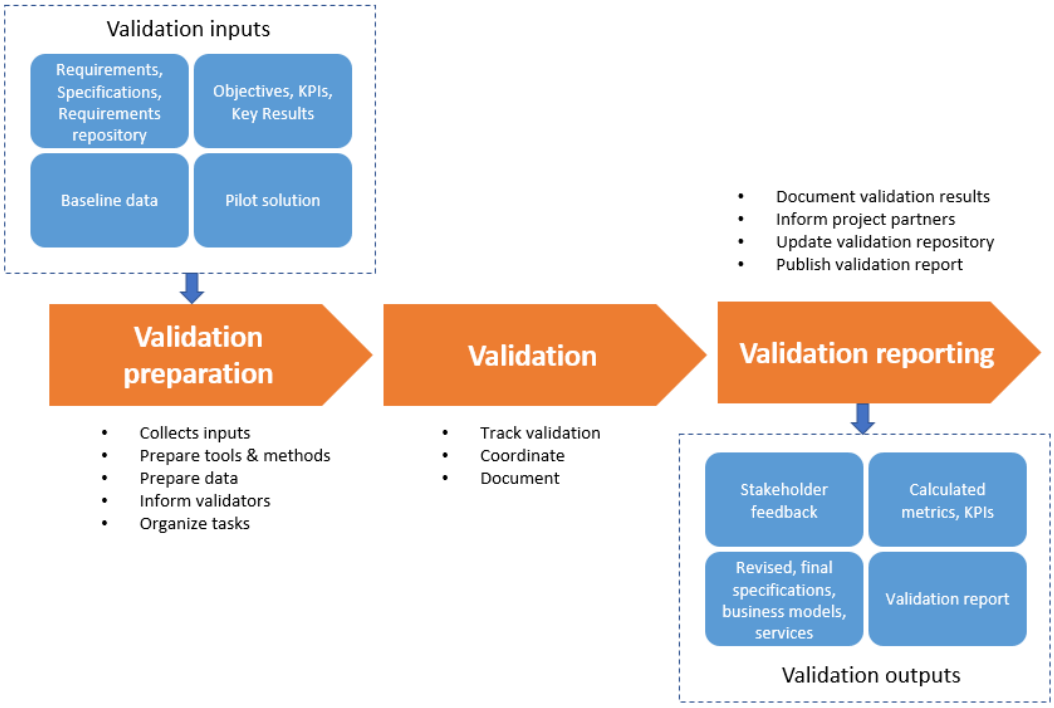

Figure 4: IFLEX individual validation iteration process

4 Validation framework and plan

Validation framework consists of four groups of validation items:

1. End user validation
2. Technical validation
3. Business validation
4. Validation based on the Description of the Action (DoA) document – KPIs

Each validation item is described with several details on the content, timing, inputs (e.g. baseline data, deliverables), responsibility, involved parties and methods for validation. Not all validation items follow the same structure since it is not relevant to all items. The table below lists all validation item's properties that are used further in the document describing validation items:

Table 2: Validation item's properties

Validation item property	Description
ID	Each validation item gets an ID that is composed of the prefix and the order number. The prefixes are: • End user validation – EUV *(e.g.: EUV1, EUV2 ...)* • Technical validation – TV *(e.g.: TV1, TV2 ...)* • Business validation - BV*(e.g.: BV1, BVV2 ...)* • Validation based on the Description of the Action (DoA) document - VDOA *(e.g.: VDOA1, VDOA2 ...)*
Validation item (description)	A short description of the validation item.
Success / Acceptance criteria	Acceptance criteria describe the minimum set of requirements that must be met by a solution or solution component. Acceptance criteria are typically used when only one possible solution is being evaluated, and are generally expressed as a pass or fail. Evaluation criteria define a set of measurements which allow for ranking of solutions and alternative designs according to their value for stakeholders. Each evaluation criterion represents a continuous or discrete scale for measuring a specific solution attribute such as cost, performance, usability, and how well the functionality represents the stakeholders' needs. Attributes that cannot be measured directly are evaluated using expert judgment or various scoring techniques

Validation method	Validation technique defines how the requirement validation should be provided. There are different techniques suitable: • Requirements review • Peer review • Focus Groups • Stakeholder evaluation (based on Acceptance and Evaluation Criteria, Metrics and Key Performance Indicators (KPIs)) • Business case evaluation • Observation • Prototyping • Survey or Questionnaire • Use Cases and Scenarios evaluation • Acceptance test
Validation inputs	Validation input lists what is required for the validation process (e.g. a set data that needs to be prepared prior to the validation process is started, deliverables, documents, user's consent etc. ...). It is important to list and to be aware of all the necessary inputs prior to the start of the validation since it might represent a blocker if inputs are not prepared when needed.
Pilot's cluster	Greek, Finnish or Slovenian. Since the iFLEX assistant will differ for each of the pilot's clusters, it should be specified whether the validation item refers to all or just of the pilot's clusters
Responsible for validation (Validation coordinator)	Each validation item should have one dedicated consortium partner who takes ownership of that item in the validation process.
Validation participants	While each validation item has a partner assigned that is responsible for its validation, we also list partners that will participate in the validation process
Validation type	Validation for each validation item can be iterative (validation process is repeated in several iterations where the requirements can also evolve in time) or one-off (validation process takes place once). Parts of the validation, such as the consumer load forecasting and the flexibility modelling will require relatively long time of operations to allow for a sound validation. Other parts, such as technology readiness and final business models, requires a one-off validation of the final outcome.
Validation period (Pilot phase 1, 2, 3)	iFLEX has three main validation periods – Pilot phase 1,2 and 3.
Validation month	The project will last 36 months and we try to set the months when the validation process for each particular item will take place.
Reference	An iFLEX deliverable, document or any other source where further details on the validation item can be found.

4.1 End user validation

The end user validation framework and plan specify the content (what), methodologies and methods (how), and planning (when) of the evaluation. As a framework it is not intended to be prescriptive or restrictive; it will set the boundaries for the validation while being flexible to accommodate to changing shape and needs of the project (the iterative approach) and its end users.

4.1.1 End User Validation Framework

As part of the user centred design approach, the users are involved in the creation, testing and validation/evaluation of the iFLEX Assistant. User validation is the answer to the question: Have we built the right system? (i.e., is this what the end users need and want?). Thus, validation is the process of evaluating a subsystem or system at the end of the development process in order to establish whether it satisfies specified user needs. End user validation is done through the implementation of the iFLEX solution in the pilots. The users are consumers/prosumers from the iFLEX pilot sites.

The purpose of user validation is to assure that the implemented result is in agreement with the needs and requirements of the (intended) end users. It is thus closely linked to the technical validation and the requirement work that will be carried out in WP2. For our purposes here, we focus on end user validation as the assessment of the user's experiences of the iFLEX solution as a tool for making participation in demand response easy and attractive. End user experience here encompasses user acceptance, satisfaction and usability, which are considered as being intrinsically linked.

Since the focus is on creating a good user experience, the following aspects of the iFLEX Assistant will be addressed in the user validation as they collectively influence the user's experience of interaction[1]:

- Functionality: Do the functions and content solve my needs, is the assistant useful and will I use it?
- Usability: Can I use it and is it an effective and efficient tool that I am satisfied with[2]?
- Pleasure: How do I feel about using the iFLEX Assistant? Does the presentation and interaction provide pleasure and value / is the assistant desirable / does it support the achievement of be-goals i.e., the motivation behind the interaction e.g., being independent, competent, etc.?

It is worth noting that usability will be done from two perspectives. First, software usability tests with end-users primarily in Phase 1 and 2 and thus part of the formative evaluation. Second, usability evaluation as an integral component of end user experience evaluation which is part of the summative validation (see also section 3.1).

Usability as part of the summative validation will focus on analysing pilot end users' concrete experiences and perceptions of how iFLEX has supported and facilitated their engagement in DR. It will thus be part of the collective assessment of the quality of use in the pilots from the end-user perspective; the pilot settings provide controlled conditions which are needed to ensure valid and interpretable results.

The methodology for assessing usability is based on the ISO/IEC 25010 for Quality of Use model (ISO/IEC, 2011). See Figure 5 which defines quality of use as "the degree to which a product used by specific users meets their needs to achieve specific goals with effectiveness, efficiency, freedom from risk and satisfaction in specific contexts of Use (ISO/IEC 25010:2011(E), p.8).

[1] ISO 9241 definition of user experience: a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service

[2] ISO 9241 definition of usability: extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. Satisfaction is defined as property of usability, more specifically: extent to which the user's physical, cognitive and emotional responses that result from the use of a system, product or service meet the user's needs and expectations. https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-2:v1:en

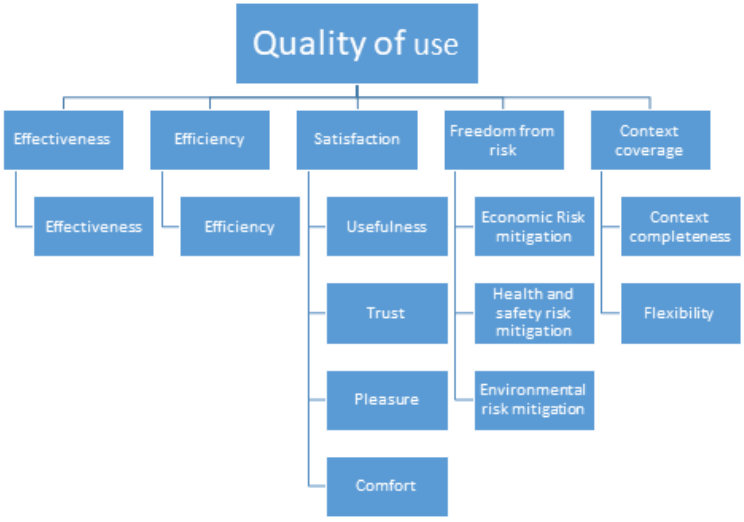

Figure 5: Quality of use model (ISO 25010)

In iFLEX, the quality of use model will be used specifically in the context of the pilots' end users (prosumers and consumers) and therefore not all five characteristics of the model will be equally relevant or assessed at the same time. Effectiveness and efficiency will thus be assessed as part of the formative evaluation primarily in Phase 1 and the results will be fed into the development and refinement of the solution for the subsequent phases. As the number of pilot end users is limited for this phase, the project will also engage the wider public (all potential end users, i.e. prosumers and consumers) in a co-creation activity where the main objective is to get input on the iFLEX concept, the iFLEX Assistant mock-ups and the use cases (described in D2.1) in a broader context.

User satisfaction will be assessed by end users in Phase 3 and thus as part of the summative evaluation. User satisfaction is of course highly subjective and is also closely related to (experiences of) usability. The characteristics "Freedom from risk" and "Context of use" will be validated by other stakeholders than end users and will therefore not be described more here.

As noted above, end user validation in the present context is specifically focused on the user experience (user acceptance and satisfaction) which will be measured using the User Experience Questionnaire (UEQ) (Schrepp et al., 2014). The validated UEQ questionnaire is useful for assessing user's experiences of using the product itself. The UEQ consists of 26 items that are associated with 6 distinct quality aspects. It uses the Likert scale for scoring, i.e. respondents must answer to which degree they agree/disagree with each statement.

The UEQ comes with a unique scoring system which allows for an automatic calculation of the scoring by using the provided Excel scoring sheet. It is possible to compare the results with a standard benchmark that allows for conclusions about the relative quality of the evaluated product compared to other products (Schrepp et al., 2015)

The UEQ contains 6 scales with 26 items:

- Attractiveness: Overall impression of the product. Do users like or dislike the product?
- Perspicuity: Is it easy to get familiar with the product? Is it easy to learn how to use the product?
- Efficiency: Can users solve their tasks without unnecessary effort?
- Dependability: Does the user feel in control of the interaction?
- Stimulation: Is it exciting and motivating to use the product?
- Novelty: Is the product innovative and creative? Does the product catch the interest of users?

In addition, specially designed questionnaires for end user validation may also be used.

4.1.2 End User Validation Plan

The plan for the end user validation is presented in the Table 3.

Table 3: End User Validation Plan

ID	Validation item (description)	Success / Acceptance criteria	Validation method	Validation input (data to be collected, documents, ...)	Pilot's cluster	Responsible for validation	Validation participants	Validation type	Validation period (Pilot phase 1, 2, 3)	Validation month
EUV1	Usability • Efficiency • Effectiveness iFLEX concept • Use cases • Functionalities and user interface	Usability: >85% General approval	• Tests • Questionnaire (s) • Workshop • Interviews	• Test data • Quantitative data from questionnaires Qualitative data from workshops/interviews	All	Pilot clusters, IN-JET, ZPS	• Pilot end users • Public (potential end users) • Technical partners	Iterative	Phase 1 & 2	M13-M14 M24-M25
EUV2	User experience & satisfaction • Attractiveness • Perspicuity • Efficiency • Dependability • Stimulation • Novelty	>Good, compared to UEQ benchmark (for each sub- item)	• UEQ	Empirical data from pilot (implementation of use cases)	All	Pilot clusters, IN-JET, ZPS	Pilot end users	One-off	Phase 3	M33-34
EUV3	User acceptance	>Good, overall result of UEQ (all items) Positive (qualitative data)	• UEQ • Focus group • Interviews • End user feedback	• Quantitative data (UEQ) • Qualitative data (focus group, interviews, feedback)	All	Pilot clusters, IN-JET, ZPS	Pilot end users	One-off	Phase 3	M33-34
EUV4	Usability and user satisfaction for active participation in DR • Usefulness • Trust • Please • Comfort	Positive (qualitative data) >85% (quantitative data)	• Questionnaire • Focus group • Interviews • End user feedback	• Qualitative data • Quantitative data (questionnaire)	All	Pilot clusters, IN-JET, ZPS	Pilot end users	One-off	Phase 3	M33-34

4.2 Technical validation

4.2.1 Technical Validation Framework

The technical validation framework will include both validation and verification activities to ensure that iFLEX meets the specifications and requirements to fulfil the defined use cases that will be deployed by the project's three pilot clusters.

In the present context we use the following broad definitions:

> **Verification** is the answer to the question "Have we built the system right?" Verification is done internally in the project by technical partners. It is a static test; verification is a quality control process used to evaluate if a system component complies with regulations, specifications or conditions imposed at the beginning of the current development phase. It is performed at laboratory level by the technical partner(s) responsible for the requirement/component.
>
> **Validation** is the answer to a different question, "Have we built the right system?" Validation endeavours to ascertain that the system or services meet the expectations and requirements of its intended users. Validation involves the end users and other stakeholders. It is a dynamic test; validation will be carried out by (through) the deployment of iFLEX in the pilots.

The technical validation framework presented here is not intended to be prescriptive or restrictive; it will set the boundaries for the technical validation while being flexible to accommodate to iterative as well as the co-creation approach adopted by the project. It will thus also allow for modifications to the use cases and requirements, thereby accounting for any changing shape and needs of the project, its stakeholders and its end-users.

The technical validation of the iFLEX Framework and the application-specific iFLEX Assistants focuses on the iFLEX use cases and the **functional and non-functional requirements** which have been elicited from the iFLEX use cases:

- **Functional requirements**
- **Security requirements**
- **Socio-economic requirements**
- **Other non-functional requirements (e.g. performance)**

Internal testing and verification activities (e.g. unit tests, debugging, integration tests and system tests, which may be manual or automated) will be carried out before the iFLEX Assistant is deployed and validated with end-users in the project's three pilots. This will be carried out for each of the three phases of the pilots in line with the agile methodology that has been adopted. This means that component development, system integration, and components/system testing are intertwined, coupled, and performed in a continuous manner. Nevertheless, in different parts of a single project phase, the main focus is on a different aspect of technical research and development. Thus, the focus cyclically shifts from component development to integration and to pilot deployment and validation (see D6.1 Continuous integration and deployment plan for further details (A. Savanović et al.)).

All use cases are described using a predefined template (see D2.1 Use cases and requirements) which allows for a detailed description of the use case and its actors. A UML diagram is also included in the template. The use case template contains the following fields (for details, please refer to D2.1):

- General information
    - Version management
    - Scope and objectives of the use case
    - Key performance indicators
    - Classification information

- High Level Analysis
  - Narrative of use case
  - Use case conditions
  - Actors
  - Use case diagram

The analysis of the use cases is used to elicit functional and non-functional requirements. As noted in D2.1, functional requirements describe what a system "must do" (behavioural attributes), detailing the functionality that is supposed to accomplish whereas non-functional requirements impose constraints on the design or implementation focusing on the operational criteria (quality attributes) e.g. performance, security, scalability, reliability, maintainability, standards compliance.

All requirements will be documented in a pre-defined template which will ensure that all requirements are documented in the same manner. **The template includes a field where the validation metric is defined: for functional requirements the "description" field will clearly state the requirement's functionality and for non-functional requirement a measurable "fit criteria" will be defined.** For the management of the requirements process, the JIRA tool has been installed and configured with the iFLEX requirement template. JIRA is a web-based issue tracker that allows implementing and tracking a collaborative workflow and is used as a tool for gathering and sharing requirements amongst developers and users. JIRA is used to manage and track all requirements. For documentation, the full description of requirements may be exported from JIRA, see Figures Figure 6 and Figure 7 below.

[IF-3] Flexibility and baseline forecasting Created: 19/May/21 Updated: 19/May/21	
Status:	In Progress
Project:	iFlex Project
Component/s:	None
Affects Version/s:	None
Fix Version/s:	None

Type:	Functional	**Priority:**	Major
Reporter:	Jussi Kiljander	**Assignee:**	Jussi Kiljander
Resolution:	Unresolved	**Votes:**	0
Labels:	DigitalTwinRepository		

Rationale:	This functionality is needed both in explicit and implicit DR.
Pilot Finland:	Phase one
Pilot Greece:	Not applicable
Pilot Slovenia:	Not applicable

Description

The iFLEX Assistant needs to provide flexibility and baseline forecasts.

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Figure 6: The full description of a functional requirement (example only), exported from JIRA

[IF-2] System Y performance Created: 16/Apr/21 Updated: 06/May/21	
Status:	Open
Project:	iFlex Project
Component/s:	None
Affects Version/s:	None
Fix Version/s:	None

Type:	Non-functional	**Priority:**	Major
Reporter:	Jesper Thestrup	**Assignee:**	Unassigned
Resolution:	Unresolved	**Votes:**	0
Labels:	None		

Rationale:	System Y shall process a minimum number of transaction transactions per second.
Component:	iFA A&M interface
Metrics:	Transactions per second
Verification:	Number of transactions in a defined time-frame
Target:	[8, 20] transactions/s

Description

System Y shall process a minimum number of transaction transactions per second.

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Figure 7: The full description of a non-functional requirement (example only), exported from JIRA

All requirements will be processed through the same pre-defined workflow which consists of 7 statuses and 11 transitions, see Figure 8 below. The requirement engineering approach and the use of JIRA is described in more detail in D6.1.

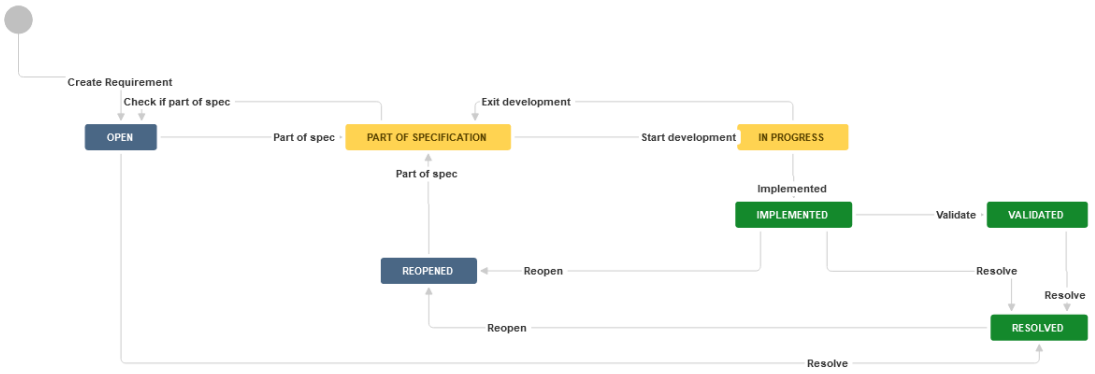

Figure 8: The Requirements Workflow (Jira)

Once a requirement is implemented it will be validated through the deployment of the use case(s) in the pilot(s). Requirements will thus be validated against functionalities described in the detailed use case narrative (complete use case description).

WP2 is responsible for the requirement engineering work and will therefore manage the technical validation and verification activities. The overall status of requirements will be document in WP2 whereas the implementation and validation of requirements will be described in the technical deliverables, notably in WP3 and WP4. The iFLEX use cases are described in D2.1 Use cases and requirements (I. Kokos et al. 2021).

4.2.2 Verification and validation methods

Technical verification and validation is based on the ISO/IEC 25010 (ISO/IEC, 2011) for Product Quality. It will focus primarily on four areas of ISO /IEC 25010 Quality model for external and internal quality (marked in figure below). A product quality model composed of eight characteristics (which are further subdivided into sub-characteristics) that relate to static properties of software and dynamic properties of the computer system. The model is applicable to both computer systems and software products.

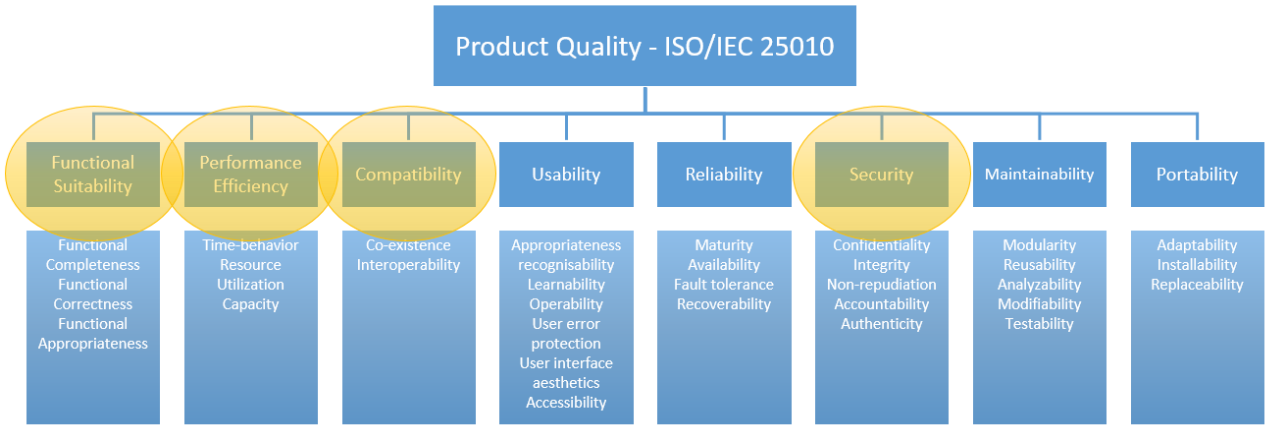

Figure 9: ISO/IEC 25010 Product Quality model for external and internal quality

To ensure requested quality of the iFLEX Framework and software specific iFLEX assistant following testing methods will be used. Table 4 illustrates the testing methods for technical validation.

Table 4: Testing methods for technical validation

Method	Description	Validation input (data to be collected, documents, ...)
Verification – Debugging	Debugging is the process of finding and resolving defects or problems within a computer program that prevent correct operation of a software	iFlex Framework and Assistant code
Verification – Unit testing	Unit testing is a type of software testing where individual units or components of a software are tested. The purpose is to validate that each unit of the software code performs as expected.	iFlex Framework and Assistant code
Verification – Integration testing	Integration testing is a process of testing involving all interconnected components of the software to ensure their interoperability.	iFlex Framework and Assistant code,
Verification – System testing	System testing includes testing of all software components, all integrations (internal and external) to ensure that a system works as a whole.	iFlex Framework and Assistant code

Validation – Functional testing	Checking functions by emulating business scenarios, based on functional requirements. Black-box testing is a common way to verify functions.	iFLEX Pilot solution, Test plan, Test cases and test scenarios
Validation – Security testing	Testing of software to ensure meeting security requirements and measures.	iFLEX Pilot solution, Test plan, Test cases and test scenarios
Validation – Performance testing	Testing how the software performs under different workloads. Load testing, for example, is used to evaluate performance under real-life load conditions.	iFLEX Pilot solution, Test plan, Test cases and test scenarios
Validation – Acceptance testing	Verifying whether the whole system works as intended from the intended user point of view	iFLEX Pilot solution, Test plan, Test cases and test scenarios

4.2.3 Technical Validation Plan

For each pilot and each pilot phase, a set of use cases will be selected for verification testing and validation in order to plan the technical validation for each iteration/pilot phase. Some use cases may be partly implemented, meaning that some of the associated requirements will be implemented in the first or second phase, e.g. only high priority requirements, with the remaining requirements implemented only in the subsequent phase. Additionally, the involvement of the end-users is expected to result in some modification of the use cases, generate additional requirements and possibly reject some existing requirements as a result of the pilot execution (validation).

The selection will in most cases be done as the requirements are defined. As noted above, the requirement template allows for the specification of which pilot and which pilot phase the specific requirement is related to as well as a definition of the metrics and goals (or fit criteria) for each requirement.

Table 5 presents the high-level technical validation plan.

Table 5: Technical validation plan

Activity	Methods/tools	Timing	Validation participants
Analyse use cases and elicit requirements (describe and document requirements in JIRA)	Text analysis Feedback/co-creation with end-users	Iterative according to pilot phases	ICOM (Lead) All partners
Perform internal **verification** activities	Debugging System tests Integration tests Unit tests	Iterative according to pilot phases: • M1-M10 • M15-M21 • M26-M32	SCOM (Lead) Technical partners
Pilot **validation** of iFLEX Framework and the application-specific iFLEX Assistants	Functional testing Security testing Performance testing Acceptance testing	Iterative according to pilot phases: • M11-M14 • M22-M25 • M33-M36	Pilot Partners (Lead) Technical partners IN-JET ZPS End-users

The timing of the technical validation activities is aligned with the project's three pilot phases and thus with the continuous integration and deployment plan defined in D6.1.

4.3 Business validation

4.3.1 Business Validation Framework

Business validation (WP5) and piloting (WP7) are fed back into WP2 to refine the overall architecture for the next phase of the iFLEX Framework and the application-specific iFLEX Assistants. The business validation will be done for designed business models and services by computing a set of financial metrics, such as Internal Rate of Return (IRR) and Return on Investment (ROI). In addition to those also objectives, KPIs and business incentives will be validated during business validation. Baseline data regarding energy consumption, and values for the cost and benefit parameters of the economic models for the calculations involved in the business validation will be provided by industrial partners and/or documented in public reports. Any assumptions involved in the values of cost/revenue parameters or in a business use case offering scenario will be explicitly stated and they will be made as realistic as possible. Moreover, assumptions will be made based on an average-case, a best-case and a worst-case scenario.

Business validation includes:

1. Validation of objectives and business-related KPIs defined in the use cases (D2.1), namely KPI4a_DoA (ROI) and KPI4c_DoA (monetary benefit for prosumer/consumer in the base scenarios) for the various use cases deployed in the pilots:
    - For each pilot phase, each pilot cluster, i.e., 3x3 per deployed use case
2. Validation of business models and services mainly using economic analysis/validation (T5.4) with STEcon 360 BME for the various stakeholders of sustainable business models (T5.2) identified with the E3Value tool. Validation of business models and services includes:
    - **New services** provided by iFLEX Framework (BUCs) and the application-specific iFLEX Assistants;
    - **Enhanced DR services** already provided by industrial partners, like, but not limited to: DR aggregation for energy markets; DR for congestions control and power balancing at the transmission system level; DR for peak reduction and RES integration in distribution networks; DR aggregation for flexibility markets; holistic energy management at building and neighbourhood levels, to name a few.
    - Different scenarios of market penetration will be considered and sensitivity analysis will be carried out for each BUC.
3. Validation of business incentives with end users (D5.4)
    - Economic analysis of business incentives value for end users. Estimate ROI for prosumers/consumers when such investment is applicable for a BUC, already covered by validation 1 above.
    - End user satisfaction with incentives provided in the various BUCs. To this end, the following metrics will be employed:
        - User engagement with iFlex assistant
            - Based on number of reports read and reacted to by the end-user without and with reporting on engagement of others (resp. KPI4a, KPI4b in D2,1)
            - Based on the number of users that engage in energy advice (KPI5a).
        - DR participation
            - Based on the number of end users that apply the energy advice successfully (KPI5b).
            - Based on the percentage of end users that asked for a new flexibility service (KPI6a).
        - Customer discomfort or user satisfaction based on customer feedback.
4. Evaluate the impact of business models to the overall society by computing an extensive set of socioeconomic KPIs according to the EC-adopted methodology for cost-benefit analysis.

Involved stakeholders for validation:

- Industry partners (i.e., DSO, TSO, Aggregator, SaaS provider, ESCO, HEMS/BEMS provider, Energy Supplier, Flexibility Procurer)
- End users

4.3.2 Business Validation Plan

Validation items for the business validation are presented in Table 6: Objectives and KPIs defined in the use cases, Table 7: Validation – Business incentives, Table 8: Business model and services.

4.3.3 Objectives and KPIs defined in the use cases

Table 6: Objectives and KPIs defined in the use cases

ID	Validation item (description)	Success / Acceptance criteria	Validation method	**Validation input** (data to be collected, documents, ...)	Pilot's cluster	Responsible for validation	Validation participants	Validation type	Validation period (Pilot phase 1, 2, 3)	Validation month	Reference
BV1	**Return on Investment**	KPI4a_DoAReturn on Investment should be more than 5%	Calculate ROI for the various use cases deployed in the pilots for each pilot phase	Realistic cost assessment (CAPEX, OPEX) of deployed infrastructure, revenue measurement for prosumers in the deployed use case.	All clusters	AUEB	Pilot partners, ZPS, INJET	Iterative	Phase 1, 2, 3	12, 24, 36	D2.1, D5.6, D5.7
BV2	**Monetary benefit for prosumer/consumer in the base scenarios**	KPI4c_DoA: monetary benefit for prosumer/consumer in the base scenarios should be more than 10% of the energy cost.	Calculate monetary benefit for prosumer/consumer based on actual energy production, energy cost and flexibility offerings	Based on measured energy production, energy cost savings and/or flexibility revenues, estimate monetary benefit for prosumer/consumer in the deployed use cases	All clusters	AUEB	Pilot partners, ZPS, INJET	Iterative	Phase 1,2,3	12, 24, 36	D2.1, D5.6, D5.7

4.3.4 Business incentives

Table 7: Validation – Business incentives

ID	Validation item (description)	Success / Acceptance criteria	Validation method	**Validation input** (data to be collected, documents, ...)	Pilot's cluster	Responsible for validation	Validation participants	Validation type	Validation period (Pilot phase 1, 2, 3)	Validation month	Reference
BV3	**User Engagement**	Number of reports read and reacted to by the end-user without and with reporting on the engagement of others (resp. KPI4a, KPI4b). KPI4a >50%, KPI4b>50% Number of users that engage in energy advice (KPI5a). KPI5a → more than 50	Measure the number of reports read and reacted to by the end-user without and with reporting on the engagement of others (resp. KPI4a, KPI4b). Measure the number of users that engage in energy advice (KPI5a).	Empirical data in the pilots, Report on engagement and participation	All clusters	ZPS	Pilot partners	Iterative	Phase 2,3	24, 36	D2.1
BV4	**DR participation**	Number of end users that apply the energy advice successfully (KPI5b). KPI5b>30% Percentage of end users that asked for a new flexibility service (KPI6a). KPI6a<20%	Based on the number of end users that apply the energy advice successfully (KPI5b). Based on the percentage of end users that asked for a new flexibility service (KPI6a).	Empirical data in the pilots. Report of end user activity (energy advice, service usage, service demand)	All clusters	ZPS	Pilot partners	Iterative	Phase 2,3	24, 36	D2.1

4.3.5 Business model and services

Table 8: Business model and services

ID	Validation item (description)	Success / Acceptance criteria	Validation method	Validation input (data to be collected, documents, ...)	Pilot's cluster	Responsible for validation	Validation participants	Validation type	Validation period (Pilot phase 1, 2, 3)	Validation month	Reference
BV5	**Feasibility of BUCs, Profitability of BUCs**	Value for end-user > 0, Benefit>Cost for the various stakeholders	E3Value	Preliminary pilot data on overall service cost and benefit	All clusters	INJET	Pilot partners, Market stakeholders	Iterative	Phase 1, 2, 3	12,24, 36	D5.1, D5.7
BV6	**Business sustainability of BUCs**	IRR>5%, Payback period < 10 years NPV for 20 years > 200% * initial investment	Economic analysis: The STEcon 360 BME	Baseline data on prices,,cost and benefit parameters for the various deployed use cases both previously available and based on the pilot infrastructure. Baseline data on various energy tariffs and estimates on market value of flexibility offers. Measurement data on energy production (for prosumers) and energy cost savings/monetary benefit of prosumers/consumers.	All clusters	AUEB	Industry partners/Market stakeholders	Iterative	Phase 1, 2, 3	12, 24, 36	D5.1, D5.5, D5.6
BV7	**Business feasibility of enhanced DR services, namely DR aggregation for energy markets (wholesale/balancing/auxiliary services), DR for balancing at the distribution network, DR for balancing at the transmission network, DR services for energy management at the household/building level**	Value for end-user > 0, Benefit>Cost for the various stakeholders	E3Value	Preliminary pilot data on overall service cost and benefit	All clusters	INJET	Industry partners/Market stakeholders	Iterative	Phase 2, 3	24, 36	D2.1, D5.7
BV8	**Business sustainability of enhanced DR services, namely DR aggregation for energy markets (wholesale/balancing/auxiliary services), DR for balancing at the distribution network, DR for balancing at the transmission network, DR services for energy management at the household/building level**	IRR>5%, Payback period < 10 years NPV for 20 years > 200% * initial investment	Economic analysis: The STEcon 360 BME	Baseline data on cost and benefit parameters for the various deployed use cases. Baseline data on various energy tariffs and estimates on market value of flexibility offers. Measurement data on energy production (for prosumers) and energy cost savings/monetary benefit of prosumers/consumers.	All clusters	AUEB	Industry partners/Market stakeholders	Iterative	Phase 2, 3	24, 36	D2.1, D5.5, D5.6

4.4 Validation based on the Description of the Action (DoA) document – iFLEX KPIs

The validation will focus on KPIs defined in Description of the Action (DoA) document. Most of the KPIs are related to use cases and should be included already into business validation. The validation should prove that promised KPIs and their target values are meet and Key results delivered.

Validation based on the Description of the Action (DoA) document includes:

- Validation of KPIs – calculate KPIs and proof of meeting target KPI values (see Table 9: Validation of KPIs (DoA))

4.4.1 Validation of KPIs

Table 9: Validation of KPIs (DoA)

ID	Validation item (description)	Success / Acceptance criteria		Validation method	Validation input (data to be collected, documents, ...)	Validation type	Validation month	Reference
		Target	Validation measures					
VDOA1	KPI1 - Number of different types of stakeholders contributing to the co-creation process.	6	Number of different stakeholders, including consumers, prosumers, DSOs, retailers, aggregators, technology providers represented and contributing to the co-design of iFLEX Assistant concept.	Count number of different stakeholders	List of stakeholders and type of stakeholder	One-off	M36	DoA
VDOA2	KPI2a - Increased accuracy of consumer load forecasting compared to state-of-the-art Methods	20%	The results are compared to the state-of-the-art consumer load forecasting models and percentage decrease of forecasting error is calculated. Evaluation is performed using a variety of data sets (collected in the project), data amounts and load forecasting lengths and average performance of the approaches is calculated.	Calculate and compare forecast error (state-of-the-art forecasting vs. iFLEX). Calculate % of error decrease (average performance).	State-of-the-art short-term load forecasts; iFLEX short-term load forecasts; Load realization by consumers.	One-off	M36	DoA
VDOA3	KPI2b - Increased accuracy of flexibility modelling compared to state-of-the-art methods	15%	The results are compared to the state-of-the-art flexibility modelling results and percentage decrease of forecasting error is calculated. Evaluation is performed using a variety of data sets (collected in the project), data amounts and flexibility forecasting lengths and average performance of the approaches is calculated.	Calculate and compare forecast error (state-of-the-art forecasting vs. iFLEX). Calculate % of error decrease (average performance).	State-of-the-art flexibility forecasts; iFLEX flexibility forecasts; Flexibility realization	One-off	M36	DoA
VDOA4	KPI2c - Increased effectiveness of automated flexibility management compared to standard methods	10%	The results are compared to typical flexibility management algorithms in a wide variety of DR optimization targets and incentives. Percentage improvement of rewards (incentive-specific) is calculated. Evaluation is performed using a variety of data sets (collected in the project), and incentives, and an average performance of the approaches is calculated.	Calculate and compare effectiveness based on standard methods vs. iFLEX. Calculate % of improvement in effectiveness (incentives applied)	Incentives; Standard methods effectiveness; iFLEX effectiveness	One-off	M36	DoA
VDOA5	KPI3a - Level of interoperability (coverage of common standards)	100%	Compliance of the iFLEX Framework with connectivity, syntactic and semantic level interoperability standards, presented in section 1.3.1.4.	Calculate % of standard applied in iFLEX	List of common standards for syntactic and semantic interoperability	One-off	M36	DoA
VDOA6	KPI3b - Compliance with relevant EU privacy and data management regulation and standards	YES	Non-binding opinion regarding the project privacy and data management approach provided by one of the pilot countries Information Commissioners (IC) office.	Gain opinion and agreement of the pilot countries Information Commissioners (IC) office	List of relevant EU privacy and data management regulation and standards	One-off	M36	DoA
VDOA7	KPI4a - Return on Investment for prosumers in the base scenarios	>15%	Validated via the iFLEX economic sustainability tool, a CBA based techno-economic evaluation under various business modelling scenarios pertaining to our environment and stakeholders and by utilising data from our trials. A sensitivity analysis will also be performed to account for alterative settings (e.g. changes to market prices and product penetration rates).	Provide CBA and calculate ROI with iFLEX. Calculate % of ROI improvement comparing base scenario and iFLEX	Prosumers base scenario data, ROI (no iFLEX), Prosumers scenario data with iFLEX; iFLEX business model	One-off	M36	DoA

VDOA8	KPI4b - Internal Rate of Return for all commercial entities in the base scenarios	>15%	Similarly, to above (KPI4b).	Provide CBA and calculate IRR with iFLEX. Calculate % of IRR improvement comparing base scenario and iFLEX	Commercial entities base scenario data, IRR (no iFLEX), Commercial entities data with iFLEX; iFLEX business model	One-off	M36	DoA
VDOA9	KPI4c - Monetary benefits to the consumer in the base scenarios	>8%	Decrease of costs for the consumer compared to current situation. Our economic sustainability tool will be used as well to demonstrate that these are feasible for all players. Monetary benefits will also be projected through the business plans of our stakeholders adopting the iFLEX Assistants (e.g. DSOs, ESCOs, etc.) after the end of the project as a result of the expected economic benefits for them (e.g. KPI4a and KPI4b) enabling further reductions for their customer base.	Provide CBA and calculate consumer costs with iFLEX. Calculate % of cost decrease comparing base scenario and iFLEX	Consumer base scenario data, Costs (no iFLEX), Consumer scenario data with iFLEX; iFLEX business model	One-off	M36	DoA
VDOA10	KPI5a - Technology readiness of the iFLEX Framework and iFLEX Assistant prototypes	TRL 7	The iFLEX Framework and application-specific iFLEX Assistants, developed with the framework, have been demonstrated in operational environment.	Validate TRL 7 measures for pilot solution with stakeholders and pilot users. Questionnaire results confirming TRL7	Measures for TRL 7, Pilot solutions, Framework, Business model	Iterative	End of each pilot	DoA
VDOA11	KPI5b - Number of innovative demand response and holistic energy management services	5	Total number of new demand response and energy services, including holistic energy management services combining energy with non-energy benefits.	Count innovative DR services – DR services not available among project partners and in pilot sites when the project started.	Baseline DR services, List of new DR services, D2.1 Use cases and requirements, D5.4 Final iFLEX consumer engagement and incentive mechanisms,	Iterative	End of each pilot	DoA
VDOA12	KPI6a - Number of consumers in the pilots	>600	Total number of consumers/prosumers in the iFLEX pilots.	Count customers involved into each pilot. Final count of all consumers involved in all pilots.	List of all consumers, prosumers and their consumer group (type)	Iterative	End of each pilot	DoA
VDOA13	KPI6b - Number of consumer groups targeted with novel demand response services	3	Total number of different consumer segments that have been engaged with demand response through the pilots.	Count customer groups involved into each pilot. Final count of all consumer groups involved in all pilots.	List of all consumers, prosumers and their consumer group (type)	Iterative	End of each pilot	DoA
VDOA14	KPI6c - Increased consumer flexibility for grid stability and RES integration	>15%	The average flexibility of pilot participants that is validated in grid stability/RES integration cases is compared to relevant results reported in the literature.					DoA

5 Validation progress monitoring

To have a good overview of validation progress, the following progress monitor will be applied – a recap table of all the validation items with just a selection of the fields and two fields added – Status and Comments. The ordering will be by the column Validation month in order to simplify chronological month-by-month monitoring.

Table 10: Validation progress monitoring table

ID	Pilot's cluster	Validation Item	Validation month (planned)	Status *(Planned, In progress, Passed, Failed)*	Comments

6 Conclusion

This document aims to define the validation framework which will be used through pilots and phases of iFLEX Assistant. The document answers questions: **What** should be validated within the project, **Who** should validate, **When** to validate and **What methods** and data should be used to perform the validation. It presents the overall process of the validation as well as details for: End user validation, Technical validation, Business validation and Validation of Project KPIs.

For the end user validation the document defines measures to assure that the implemented result is in agreement with the needs and requirements of the (intended) end users. In this context the validation of iFLEX assistant will focus on evaluating user experience, user acceptance and usability. Methods like User Experience Questionnaire (UEQ) and interviews will be used.

For the technical validation the document defines verifications and validations to assure that pilot solutions meet functional and non-functional requirements. The focus will be on validating functional requirements, security requirements, socio-economic requirements and other non-functional requirements (e.g. performance). Several methods are planned to be used, like: debugging, unit testing, integration testing, system testing, functional testing, security testing, performance testing, and acceptance testing.

For the business validation the document defines a framework for validating designed business models and services by computing a set of financial metrics, such as IRR and ROI. The focus will be on validating objectives and KPIs defined in the use cases, validating business models and services, validating business incentives with end users. Methods like STEcon 360 BME, IRR, ROI, DR acceptance ratio will be used.

For the Project KPIs the document defines methods and data inputs that should be used for the calculation of KPIs defined in DoA document.

The validation framework, presented in the document, clearly sets the boundaries for validation while being flexible to accommodate to iterative as well as the co-creation approach adopted by the project. It will thus also allow for modifications to the use cases and requirements, thereby accounting for any changing shape and needs of the project, its stakeholders and its end-users.

7 List of figures and tables

7.1 Figures

7.2 Tables

8 References

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